

breadth of abdomen 8; length of tegmina 22, breadth of tegmina 6; breadth of marginal field 1.5.

The above description was drawn up from the living insect.

Hab. Sylhet and North Cachar hills, Assam.

The specimen has since been compared with the mutilated type in the Oxford Museum by Professor Westwood and myself, and found to agree perfectly therewith. The discrepancy between Westwood's figure and the above description as to the structure of the discoidal vein of the wings is explained by the bad state of preservation of the typical specimen.

IV.—Notes on the Genus *Gyracanthus*, Agassiz.

By Dr. R. H. TRAQUAIR, F.R.S.*

1. *Did Gyracanthus possess dorsal spines?*

Although Agassiz himself pointed out that the spines of *Gyracanthus* were not bilaterally symmetrical, inasmuch as one side was more rounded than the other, he nevertheless regarded them as dorsal, and so did people in general, until in 1863 Messrs. Kirkby and Atthey pointed out the probable pectoral nature of some at least of these appendages, the grounds for this conclusion being the conspicuous lateral curvature shown by such specimens, along with the wearing away of the apices, as if they had been subject to habitual attrition at the bottom of the water in which their possessors lived. In 1868 Messrs. Hancock and Atthey returned to the subject †, and, reviewing the extensive series of specimens in the collection of the last-named gentleman, divided them into two categories—first, those with lateral curvature and worn apices, and second, those in which apparently there was

* Read before the Royal Physical Society of Edinburgh, December 19, 1883.

† Ann. & Mag. Nat. Hist. (4) 1868, vol. i. p. 368. In a footnote Messrs. Hancock and Atthey refer to a paper by Messrs. Atthey and Kirkby, entitled "Fish-remains in the Coal-measures of Durham and Northumberland," as having been read before the British Association at Newcastle in 1863, and as containing the first suggestion of the paired nature of these spines. I cannot find this paper in the British Association's 'Proceedings' for that year; and although a paper of the same title is found in the 'Proceedings of the Tyneside Naturalists' Field Club,' it contains no reference to *Gyracanthus*. These original remarks would therefore seem not to have been published.

only an antero-posterior curvature and in which the apex was entire and pointed. The former set, which could also be arranged in pairs, they regarded as *pectoral*, the latter as *dorsal**.

The occurrence of numerous spines of this genus in the Blackband Ironstone of Borough Lee, near Edinburgh, having lately induced me to inquire into the whole subject of *Gyracanthus*, I was surprised to find that, among the numerous specimens which came under my observation from that and other localities in Scotland, there was not one which was bilaterally symmetrical, and which consequently could be assigned to a median position. On this subject I published a few remarks in the 'Geological Magazine' for December 1882. To pursue the subject further it was, however, absolutely necessary to reexamine the specimens in the Atthey collection, now in the museum at Newcastle-on-Tyne. And having recently visited that city, I must here express my cordial thanks to my friends Mr. W. Dinning, Secretary of the Newcastle Natural-History Society, Mr. R. Howse, Curator of the Museum, and Mr. J. Hancock, member of committee, for the kind and liberal manner in which they afforded me every facility for examining the specimens in that remarkable collection of Coal-measure vertebrate remains.

Although I have not seen the original type of Agassiz's *Gyracanthus tuberculatus*, I have no hesitation in referring to it the great majority of the specimens from Newsham in the Atthey collection, and they form, indeed, a most beautiful and instructive series. And as no systematic description has been given of this form since the time of Agassiz, who had only a drawing of a mere fragment to go upon, it will not be out of place to enter somewhat into detail as to the configuration of these spines.

Proceeding first to the consideration of those labelled "pectoral" in the Atthey collection, one very fine example is $15\frac{1}{4}$ inches in length by $2\frac{1}{4}$ in diameter at its widest part near the base; its distal extremity is obliquely truncated or worn off on the anterior aspect, and the whole spine, when looked

* In a paper on *Tristychius*, published in the Ann. & Mag. Nat. Hist. for September 1883, Mr. T. Stock states, with regard to Messrs. Hancock and Atthey's views as to the pectoral nature of certain *Gyracanthus*-spines, that he has "been able to confirm their conclusions by the finding of an interesting specimen containing well-preserved remains of the pectoral arch," and refers to a paper on the subject, read by himself to the Edinburgh Naturalists' Field Club. However, on consulting the paper, now published (Trans. Edinb. Nat. Field Club, vol. i. pt. 2, pp. 50-51), it turns out that the "pectoral arch," in this case, is Messrs. Hancock and Atthey's "carpal bone," of which more anon.

at from the front, displays a well-marked lateral curvature or bend, which enables us to distinguish a convex and a concave side. It will also be observed that the lateral surface is more gibbous or rounded on the convex aspect of the spine, flatter on the opposite, so that for purposes of description we may distinguish the two sides as "gibbons" and "subgibbous" respectively. Still regarding it from the front, it will be seen that the sculptured surface ends proximally in an acute angle; but the apparent middle line on which the tuberculated or "gyrating" ridges meet *does not bisect* this angle, but divides it so that the sculptured part is larger on the gibbous side. Now, turning the spine over so as to look at it from behind, we observe that the longitudinal cleft or sulcus leading into the central cavity is not in the middle of the non-sculptured inserted part, but is placed more towards the subgibbous side, so that we have here from the very beginning a marked deviation from bilateral symmetry, one side, the convex or gibbous one, being larger than the other. We next observe that, from the distal closure of the sulcus, the lip on its subgibbous side is continued onwards towards the apex as a blunt keel or margin, having on the gibbous side a shallow longitudinal depression or groove. Thus the spine has now become keeled or marginated posteriorly, and from this margin round to the line of convergence of the gyrating ridges in front the surface on the subgibbous side is narrower and flatter, while on the opposite or gibbous aspect it is more extensive, more rounded, and provided with the aforesaid longitudinal groove. I have already, on a previous occasion*, pointed out that the groove is obviously equivalent to the posterior flattened area in such median spines as *Ctenacanthus*, but here turned *awry* and looking to one side, while the posterior marginal ridge represents one of the denticulated margins in the last-named genus; the other is to be looked for in the opposite or feebly-marked edge of the groove on the gibbous side in *Gyracanthus*. The sculptured or gyrating ridges are on the whole pretty straight and parallel in their course, though they show a slight tendency to a sigmoidal direction, curving a little towards the apex in front, towards the base behind, as well as increasing progressively in obliquity from the base onwards. They are closely tuberculated along their whole extent, and are continued as lines of tubercles over the lips of the posterior groove, in the bottom of which they converge and meet. In the above described specimen the groove is filled with tubercles as far as the spine reaches; but in others the groove becomes bare of tubercles at a variable distance

* Geol. Mag. dec. ii. vol. ix. (1882), p. 542.

from the closure of the sulcus, and only marked by delicate longitudinal striæ, while in one I find it devoid of tubercles along its whole extent. In some too, before the truncation of the apex occurs, the gyrating ridges tend to lose their close tuberculation, at least posteriorly, and to become only distantly nodulose or even quite plain.

Putting the wearing of the tips altogether aside as a secondary question, the striking want of bilateral symmetry in these spines, together with their occurrence in "rights and lefts," amply justifies the opinion of Messrs. Kirkby, Atthey, and Hancock that they were pectoral or at least paired appendages. Which are the right and which the left spines it is, however, at present not very easy to determine. Accepting the sulcated aspect as posterior, it would be necessary to ascertain whether the flat or the gibbous side was superior in order to indicate to which side of the fish it belonged.

Now, turning to the spines labelled "dorsal" in the same collection, we find that they are smaller in size, varying in length from $4\frac{1}{2}$ to $10\frac{1}{2}$ inches, and almost all lying laterally compressed on pieces of shale. In this way the lateral curvature is obscured, though in one, also marked "dorsal," which happens to be only obliquely placed on its matrix, this curvature is quite obvious. Furthermore, all of them show in other respects the same want of lateral symmetry which I have just described in those acknowledged to be pectoral, namely the possession of a flat and of an inflated and grooved side; in fact they are rendered still more asymmetrical than the large truncated spines by the much greater prominence and sharpness of the posterior marginal keel, which we have seen is morphologically a lateral structure in the general plan of the spines. This keel is also furnished with a row of small closely-set recurved denticles. The gyrating ridges become very oblique towards the point, and tend to become plain or only distantly nodulose, except perhaps on the front of the spine. On the flat side a space bare of ridges runs down from the point along the posterior margin for about $1\frac{1}{2}$ inch, and an analogous appearance is also observable on the grooved side. The groove itself is smooth and marked with delicate longitudinal striæ; and, as Messrs. Hancock and Atthey have already noted, the point is much compressed laterally*.

If we next compare the proximal or basal end of one of the

* These young spines of *G. tuberculatus* bear an extreme resemblance to the figure of *G. denticulatus*, Davis, in Ann. & Mag. Nat. Hist. (5) vi. 1880, p. 373, being similar in shape, in the characters of the gyrating ridges, and the denticulation of the posterior margin, while the same bare space runs down for a little distance from the point. Mr. Davis, however, states that his spine has *two* rows of denticles posteriorly.

largest of these supposed dorsal spines with the distal extremity of one of the least worn of those labelled "pectoral," we find a mutual approximation in character; and, further, if we compare both with an allied species, *G. nobilis*, Traq., from the Edinburgh district, pretty large specimens of which sometimes occur with the points very slightly worn indeed, the whole matter is cleared up. I have now no longer any doubt that the spines of *Gyracanthus tuberculatus*, supposed by Messrs. Hancock and Atthey to be "dorsal," are simply young specimens of the very same spines classed by them as "pectoral," and represent the distal portions or extremities, which in the adult spines have been lost by attrition. These spines increased by progressive growth at the base, and as they grew, progressive differences in sculpture, amount of lateral compression, and so on manifested themselves; so that the young spine is not a miniature of the old one, but represents only a distally situated portion of it, greater or less as the case may be. And in the case of the Newsham specimens of *Gyracanthus tuberculatus*, I may mention, as a final and convincing proof, that, although Messrs. Hancock and Atthey state that in the spines supposed by them to be dorsal the pointed extremities "are all perfect, not being in the least worn," I find in one so labelled, a specimen 11 inches in length, very distinct wearing already in progress just in front of the tip.

Although Messrs. Hancock and Atthey's dorsal spines of *Gyracanthus* are certainly not so, and although, since my attention was directed to the subject, I have not been able to find in any collection, public or private, spines of this genus to which I could assign a median position, and am consequently inclined to doubt the presence of dorsal spines altogether, I do not mean to affirm that the subject is thereby closed. Further investigation is necessary into the Irish Lower Carboniferous *G. obliquus* of M'Coy*, and into two American species named *G. compressus* † and *G. Alleni* ‡ by Prof. Newberry, the published figures of which do not indicate a want of lateral symmetry. M'Coy gives an outline of the transverse section of *G. obliquus* from a position considerably proximal to the point, in which the two sides with the posterior area seem as symmetrical as in a *Ctenacanthus*. In such a spine it would be well to examine the extreme point. There is in the collection of the Geological Survey of Scotland a rather young spine from the Liddesdale beds, which I am

* Palæozoic Fossils, p. 629, pl. iii. k, figs. 13, 14.

† Pal. Ohio, vol. i. p. 330, pl. xxxvii. figs. 1, 2.

‡ *Ib.* p. 331, pl. xxxvii. fig. 3.

inclined to refer to *G. obliquus*, and in it, near the tip, the transverse section has a form much resembling in general characters that in M'Coy's figure; but one margin of the groove is nevertheless a little more prominent than the other. It is to be hoped that American palæichthyologists will carefully examine the spines of *Gyracanthus* occurring in their country with special reference to the present question.

2. *The supposed Carpal Bones of Gyracanthus.*

Of constant occurrence in the same beds with *Gyracanthus* spines, and often found closely associated with them on the same slabs of stone, are certain peculiar bones, first noticed by Messrs. Hancock and Atthey, and by them interpreted as "carpal" bones. These occur of two forms or shapes, the first of which was described by the above-named authors in 1868*. It is a flat triangular bone, with a thick apex opposite to a thin base; and two other sides, one of which, the longer, is slightly convex, the other, or shorter, being straight or slightly concave: of the two surfaces one is slightly convex, the other slightly concave in general contour. Of these Messrs. Hancock and Atthey say, "Their structure is very open; and as they are seldom well preserved, they are probably only imperfectly ossified; the bony fibre radiates from the apex to the expanded base. There can be little doubt that these are carpal bones similar to those in connexion with the pectoral fins in sharks and dog-fishes."

The second form is briefly noticed by the same authors in another communication published four years later, and its form is described as follows:—"This second form is probably the inner carpal; it is a broad flat bone irregularly bilobed or somewhat reniform, with one of the lobes produced and the external margin straightened; the convex border is a little flattened, angulated, and thickened, thence the bony fibres radiate to the opposite or lobed margin. . . . The texture of the bone is quite similar to that of the large triangular carpal, namely, it is of a semicartilaginous appearance, with coarse radiating fibres extending from margin to margin"†.

In other passages Messrs. Hancock and Atthey clearly indicate that they considered the thin margin, in both forms, to be distal, and the apex, or point from which the "bony fibres" radiate, to be proximal in original position.

Before making any critical remarks on the above determination of the bones in question, it is necessary to fix accu-

* Ann. & Mag. Nat. Hist. ser. 4, 1868, vol. i. p. 369.

† Ann. & Mag. Nat. Hist. ser. 4, 1872, vol. ix. pp. 260, 261.

rately to what elements of the Selachian skeleton Messrs. Hancock and Atthey compare them.

The term "carpal" is not used by anatomists of the modern school to denote any part of the skeleton of the fore limb in fishes; but on turning to Prof. Owen's 'Comparative Anatomy of the Vertebrata,' vol. i. p. 168, fig. 104, we find the three basal cartilages of the pectoral fin of the picked dogfish so designated. Two of these, the *mesopterygium* and *metapterygium* of Gegenbaur, are triangular, with their apices directed towards the shoulder-girdle, while the third or *propterygium* has an oblong shape, faintly reminding us of the second form of so-called carpal of *Gyracanthus*. There can thus be no doubt that these basal cartilages, which, in the skeleton of the recent shark, intervene between the shoulder-girdle and the radial cartilages, or cartilaginous fin-rays, are the elements which Messrs. Hancock and Atthey meant by the term carpal. And the question is simply this, Is it likely that the process of calcification in such cartilages would give rise to bodies like the peculiar bones so often found associated with the spines of *Gyracanthus*? Or can any better explanation of their nature be suggested?

One point in their external configuration was not noticed by Messrs. Hancock and Atthey, namely, that these bodies were hollow, and that their extreme flatness is due to the crushing together of the thin walls of the internal cavity. If we take first one of the triangular series, it may easily be seen that the two walls, or laminae of which the bone is composed, are united at the apex and along the two thick sides which meet at the apex, but that they are separate at the thin base, at which accordingly the cavity was open. It may also be seen that the edges of the basal opening do not coincide, as careful development of these edges shows that the one on the convex side of the bone is indented by a large angular notch or sinus, which runs up for some distance in the direction of the apex; this appearance I have seen in every case in which I have looked for it. The internal cavity is at once distinguishable, filled with matrix, when a specimen is broken or cut across. I have equally assured myself of the hollow character of the bones of the second series.

If we now look at the texture of these bodies we shall be at a loss to explain the expressions "imperfectly ossified" and "semicartilaginous," used by Messrs. Hancock and Atthey, in the passages already quoted. On examining the surface with a lens its apparent fibrous aspect is seen to be due to its being closely covered with minute grooves interspersed with small openings, these markings being clearly

vascular in their nature and of the same essential character as those on the inserted portion of a Selachian spine, only not so regularly parallel as is usually the case in the latter. On making microscopic sections, transverse and longitudinal, through the substance of the supposed "carpal bone," it is found to be completely traversed by a close network of vascular or Haversian canals, the canals in some parts enlarging so as to give a rather more open character to the tissue than is found in the internal part of a *Gyracanthus*-spine itself, while the ground-substance, hard and calcareous, is permeated by minute branching and anastomosing tubules, which are frequently seen to radiate from the vascular canals. This is not, however, the structure which Selachian cartilage assumes when calcified or "ossified"*; on the contrary, if the tissue be not vascular dentine, it is certainly very like it.

I am therefore of opinion, that the bodies in question have nothing to do with "carpal bones," or with the endoskeleton of a shark at all, but that they were, on the other hand, dermal appendages, which may probably enough have been situated in the neighbourhood of the pectoral fin, the thin or open side being proximal and the apex distal. The want of enamel, or of sculpture on any part of the surface, shows that they must have been covered with a thin layer of skin. Their frequent occurrence in close relation to the spines of *Gyracanthus* renders it, indeed, highly probable that they belong to the same fish.

I hope, on a future occasion, to enter more minutely into the microscopic structure, both of these bodies, and of the *Gyracanthus*-spines themselves.

3. *On two new Species of Gyracanthus.*

In the 'Geological Magazine' for last month (Nov. 1883) I have given brief diagnoses of two new species of this genus from the Carboniferous Limestone series of Scotland, concerning which I propose, in the present communication, to enter a little more into detail.

Gyracanthus nobilis, Traquair.

Gyracanthus tuberculatus, Traq. Geol. Mag. dec. ii. vol. viii. 1881, p. 34.

Gyracanthus nobilis, Traq. *ibid.* dec. ii. vol. x. 1883, p. 542.

The spines which I have named *Gyracanthus nobilis* are of

* For an account of the structure of calcified Selachian cartilage, see Williamson on the "Structure and Development of the Scales and Bones of Fishes," Phil. Trans. 1851.

common occurrence in the ironstone worked at Borough Lee, near Edinburgh, belonging to the Middle Carboniferous Limestone series of Central Scotland; and I have also seen a fragment from a similar horizon at Cowdenbeath, in Fifeshire. At first I confounded them with *G. tuberculatus*, Ag., but the accession of more extensive material, along with a closer investigation of the subject, soon convinced me of their specific distinctness.

Gyracanthus nobilis attains a large size. One spine in my own collection, wanting a small portion of the base, but having its extreme point preserved, measures 21 inches; had it been entire its length could not have been less than 2 feet. Another, wanting the point, must have been about the same size; and fragments are not uncommon which indicate still greater dimensions. The general form is elongated and slender, the breadth increasing more rapidly towards the base in adult specimens. They are very variable in respect of curvature: in some both antero-posterior and lateral curves are well marked; in others the lateral bend is only slight or hardly perceptible; and I have one which appears almost perfectly straight in both directions. Every one of them, without exception, is nevertheless asymmetrical as regards those special points of configuration upon which I have dwelt in connexion with *G. tuberculatus*, and, as in that species, they may be arranged in pairs.

In the form of the non-sculptured inserted part, with its posterior sulcus, and in the general configuration of the spine as seen in transverse sections, *G. nobilis* closely resembles *G. tuberculatus*. The posterior marginal keel is in its distal portion strongly denticulated; in one specimen the denticles may be traced, from the point, a distance of 10 inches in the direction of the base. The posterior groove varies much in its degree of sharpness; in some it is very shallow and slightly marked till towards the point, while in others it is very well defined along its whole extent. In adult specimens continuations of the gyrating ridges usually eneroach upon it at its commencement; but the salient point in this species lies in the disposition and mode of tuberculation of these ridges. At the proximal end of the spine, in adult examples, they are disposed much as in *G. tuberculatus*, meet each other anteriorly at much the same angle, and are closely tuberculated along their whole extent. But near the closure of the sulcus this close tuberculation becomes limited to the anterior aspect, each ridge as it arises and advances forward showing first a comparatively distant tuberculation, then a smooth space (sometimes very minutely crenulated) on the side of the

spine, and finally becoming thick and coarsely tuberculated as it turns round to the front. Where this feature of the ridges commences *they also become excessively oblique and very delicate*, and in some specimens they also occasionally bifurcate along the sides of the spine; but in front, where the tuberculation appears, *they become coarse and curve a little forward*, so as to become less oblique, and in many cases they turn slightly again towards the point just before meeting those of the opposite side. Towards the extremity the ridges become entirely smooth on the sides of the spine, their slight curvature also ceases, and the tuberculation of the anterior aspect gives way to simple undulation. The point, even where it is not positively truncated by attrition, looks smooth and rubbed.

Gyracanthus nobilis may easily be distinguished from both *G. formosus* and *G. tuberculatus* (probably only varieties of one common species) by the direction of the gyrating ridges. In the latter forms these ridges are disposed in a pretty straight and parallel fashion over the sides of the spine, although they do increase in obliquity towards the apex. Here, however, their excessive obliquity and delicacy along the sides, after the closure of the sulcus, give the sculpture a peculiar aspect which cannot be mistaken. The tuberculation of the ridges is in general coarser than in *G. tuberculatus*, and, in the latter, it is only pretty well towards the apex that the ridges tend proximately to become plain, or only distantly nodulose. Of course, as regards the disposition of tuberculation, this new species differs still more from *G. formosus*, in which the ridges, from the very base, tend to be plain in front.

Adult specimens of *G. tuberculatus* show invariably, so far as I have observed, a strongly-marked lateral curvature; in *G. nobilis*, as we have seen, its presence and amount is very variable.

The course of the ridges, the disposition of the tuberculation, and the form of the transverse section equally distinguish it from *G. obliquus* of M'Coy, and it is certainly not *G. denticulatus* of Davis. Nor can it be shown to be identifiable with any of the North-American species named by Prof. Newberry and Dr. Dawson.

There only remains the *G. alnwickensis* of Agassiz, which is recorded from a somewhat similar horizon, viz. the Carboniferous Limestone series of Alnwick, in Northumberland. This is very briefly mentioned by Agassiz as being slender in form, with very oblique and entirely smooth or non-tuberculated ridges, which ridges also bifurcate, and even trifurcate, in a very remarkable manner, as shown in the figure. If this

description is correct *, *G. nobilis* is even more distinct from *G. alnwicensis* than from any other.

One remarkable feature in these spines as occurring at Borough Lee is the small amount of apical wearing to which they have for the most part been subjected. Even the extreme point, only a little blunted and polished, is sometimes present in large specimens, and in many others comparatively little of the extremity has been lost by that process which has reduced some of the large *Gyracanthus*-spines from Northumberland and Staffordshire to mere stumps. It has been noted that this wearing process has obliquely truncated the Northumbrian specimens in their anterior aspect; but in those from Borough Lee evidence of wearing is sometimes found on the posterior aspect as well. These circumstances would lead us to infer some difference either in the habitat or the habits of the species in question.

Gyracanthus Youngii, Traq.

Gyracanthus Youngii, Traq. Geol. Mag. dec. ii. vol. x. 1883, p. 543.

Occurring also at Borough Lee, but found likewise in many other localities on the horizon of the Scottish "Edge" Coal or Middle Carboniferous Limestone series, is a remarkably distinct species of *Gyracanthus*, to which I have given the name *C. Youngii*, in honour of my friend Mr. John Young, of the Hunterian Museum, Glasgow, who has done so much for the elucidation of the palæontology of the west of Scotland. The finest specimens I have seen are in the collection of Mr. R. Craig, Beith, Ayrshire, and are from the shale overlying the Clay-band Ironstone at Barkip, Dalry. I have also seen specimens from Bo'ness in Linlithgowshire (collection of Mr. H. M. Cadell), Possil in Lanarkshire (collection of Mr. John Young), Cowdenbeath in Fife, and Maryhill near Glasgow.

These are large spines, some of which must have attained a length of over 2 feet, had not their apices been worn off. They always show some amount of lateral curvature; but the degree to which they are antero-posteriorly bent is very

* Possibly it is not, as Agassiz never saw the specimen, but drew up his description from a drawing sent to him by Messrs. Buckland and De la Beche. As reproduced in the plate in the 'Poissons fossiles,' this drawing looks like a very hurriedly executed pen-and-ink sketch, from which it is quite impossible to identify any thing. Under these circumstances doubt whether the term "*alnwicensis*" has any more value than a mere manuscript name.

variable; some are indeed in that direction nearly quite straight.

The first salient point which strikes the eye is the great size of the inserted or non-sculptured portion, which is not only broader and more expanded, but extends further beyond the sculptured part proximally than in any other species. The anterior middle line on which the gyrating ridges meet does not cut equally the very acute angle formed proximally by the sculptured part; but in this case the larger division is found on the subgibbous side, this being due to the encroachment of the non-sculptured part on the gibbous side. It is next to be noticed that the shaft of the spine after the closure of the sulcus is more cylindrical than in other species; still the want of bilateral symmetry is very obvious, and a gibbous and subgibbous side may be distinguished. The posterior groove is sometimes not apparent for some distance after the closure of the sulcus, or, though indicated, it may be filled with tubercles; sooner or later it becomes well marked, and the lip on the subgibbous side becomes more prominent than the other, but does not form so marked a feature in the configuration of the spine as the corresponding posterior marginal keel in such species as *G. tuberculatus* and *nobilis*; it is in fact only towards the extremity, that the spine takes on a keeled appearance. A well-marked row of recurved denticles occurs along the aforesaid lip or ridge of the posterior groove on the subgibbous side, and on that of the opposite side denticles are also seen in some examples. The last remarkable feature in this species is the slight obliquity of the gyrating ridges, which meet each other on the front of the spine at angles greater than right angles almost as far as the very apex. These ridges are also rather less oblique on the subgibbous than on the gibbous side; on the former they are in fact sometimes nearly transverse; a certain amount of sigmoidal curvature is assumed after the middle of the spine, the anterior extremities of the ridge turning slightly towards the apex, their posterior extremities towards the base. Only towards the apex have the ridges any marked obliquity in their middle portions, and there they often also become wavy. The gyrating ridges are closely tuberculated over their whole extent, except towards the apex, where the tuberculation tends to become irregular. The amount of apical wearing is very variable.